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CONTENTS

PAGE.

FUNGI ON TEA ROOTS 1

FACTORY REQUIREMENTS FOR THE MAKING OF GOOD TEA 11

NOTES ON BAMBOOS 21

METEOROLOGICAL OBSERVATIONS IN NORTH EAST INDIA, 1928 34

FUNGI ON TEA ROOTS.

BY

A. C. TUNSTALL.

Rosellinia arcuata, Petch. The root fungus : The Stump Rot, now called Black Root Rot.

Refs :—Watt and Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 411.

Butler, "Fungi and Disease in Plants," p. 435.

Petch, "Diseases of the Tea Bush," p. 133.

Indian Tea Association, Pamphlet 1, 1918, "Tea Roots," Part II.

Indian Tea Association, "Quarterly Journal," 1914, Part I, p. 38.

Found in all tea districts and also in South India.

History :—Species of *Rosellinia* were reported from the beginning of the Indian tea industry. At least three species of *Rosellinia* are present. The commonest species of *Rosellinia* found on tea and which was formerly considered to be *Rosellinia bothrina* was named *Rosellinia arcuata* by Petch in 1917. It occurs in Ceylon and Java. Besides tea it has been found on Rahar, Indigo, Mango, *Grevillea, Erythrina, Symplocos* and several other plants. The second species which is of rare occurrence has not been definitely identified yet. The third one *Rosellinia bunodes* is however also very uncommon.

Description :—*Rosellina arcuata* frequently originates in a mass of decaying leaves. The fungus forms a loose cobwebby mass round the root. On older bushes the mycelium soon forms black strands closely applied to the surface of the root. The mycelium on the exterior penetrates the cortex and spreads out over the wood to form a white star about ¼ to ½ inch in diameter. These stars are easily seen if the outer layer of the root be carefully peeled off. Above ground the fungus grows up the stem to a distance of about six inches, forming a steel grey stocking which soon turns black. The black stocking produces a variety of spores called conidiospores which are borne on short

bristle-like stalks. The stalks occur in clusters on the sheet of mycelium giving it a velvety appearance. The stalks are branched above and at the end of each branch the conidia are produced. The conidia are one celled, narrow-oval bodies measuring about 4—6 by 2 μ in diameter. The spores are easily detached from the stalks and are transferred from place to place by the wind, the clothing of coolies, etc.

Another kind of fructification is produced, generally on branches about six inches above ground, some months after the death of the bush. It is composed of small spherical bodies about the size of small shot, about 1/10 inch in diameter growing side by side to form clusters on the grey stocking of mycelia at the base of the stem. The spores which are called the ascospores are produced within sausage-shaped sacs called asci, which develop inside these spherical bodies known as perithecia. Each ascus contains 8 spores in one row. Thread like structures known as paraphyses are present. The ascospores are black, boat-shaped, with pointed ends. They measure 40—47 by 5—7 μ.

Sometimes the bush is ringed at the collar, as a result of an attack by this fungus. The plant usually attempts to repair the injury by swelling above the diseased portion and sending out rootlets. Sometimes the injury is repaired but usually the ringed stems die. The fungus frequently dies away after causing the death of the stem leaving no trace to give a clue to the cause of the injury, which appears as if it has been gnawed by some animals.

The fungus which produces a brown incrustation on roots described by Watt and Mann is really the Brown root rot (*Fomes lamaoensis* = *Hymenochaete noxia*) of tea which is altogether a different fungus from the *Rosellinia*.

Depredations :—It seems to cause most damage on the stiffer soils especially under excessive shade. It is not, however, confined to shady places. It is most common on gardens in the West of Darjeeling but it is also present in Upper Assam where, however, it has not caused any serious damage.

Remedies :—It is an easy disease to cure, if taken in time. The dead bushes should be dug out at once and burnt. Clean away jungle, lay bare and lime wash the collars of all the surrounding tea bushes. Improve the drainage if necessary.

Where only a branch or two on a bush have been killed and the bush is still vigorous, the pruning out of the dead branches and the thorough cleaning and lime washing of the collar and thick stems will prevent further damage. The fungus is easy to kill and only thrives under special conditions.

Trenching is useful in cases where the dead bushes cannot be removed at once but it generally involves as much labour as the removal of the dead bush. It is only recommended therefore in the case of comparatively large areas of dead bushes. The trench should then be dug so as to enclose two complete lines of apparently healthy bushes and when time permits all the bushes within the trench, dead, dying and apparently healthy ones should be dug right out every bit of wood being removed from the soil and burned. It is generally more satisfactory to take out a complete rectangle as replanting is then more easily supervised.

Ustulina zonata (Lev) Sacc.

Charcoal stump rot.

Refs :—Butler, "Fungi and Disease in Plants," p. 438.
Petch, "Diseases of the Tea Bush," p. 141.
Indian Tea Association, Pamphlet, "Tea Roots," Part II, 1918.

Found in all the tea districts of North East India, South India and Dehra Dun.

History :—The fungus was first described by Leveille as *Sphaeria zonata*. In 1882 it was redescribed in Saccardo as *Ustulina zonata*. It has long been known as a common parasitic and saprophytic fungus in the tropics. In 1911 it was observed by the writer to be very common in the tea districts of

North East India. It was noted in 1913 by Sharples to be causing a serious stem disease of rubber in the Federated Malaya States. It is found in Ceylon, Java, and also in Nyasaland. The disease has been found on *Grevillea*, Pomelo (*Citrus decumana*), *Albizzia moluccana*, Sal, Boga medeloa and Rahar plants.

Description :—The disease is one of the commonest root diseases of tea in North East India. It is more frequent on sandy soil than on clay but it is not unknown on stiff silty soil.

Bushes attacked by this disease usually present an unhealthy appearance for a week or two before their death. Death comes suddenly often during wet weather.

The external appearance of the diseased root is not characteristic—a few black spots are sometimes seen scattered here and there. These are agglomerations of the mycelia which have emerged from inside of the bush and failed to progress further to form fructifications on account of their being situated underground. The fungus grows most freely between the bark and the wood and if the bark be removed the wood will be found covered with beautiful delicate white fan-shaped patches of mycelium which extend into the live portions of the tissues. As the disease progresses the extreme edges of these fans sometimes become black. Irregular black lines are seen penetrating the wood of the root when it is cut. It should be noted however that other fungi also form black lines in the wood of tea bushes so that the lines cannot be regarded as peculiar to this disease.

The fine fan-like plates of white mycelium which spread over the wood differ in appearance from those produced by the other root fungi of tea and may be considered characteristic of the disease.

After a time the fructification of the fungus appears as a soft white plate at the collar of the diseased bush. This plate usually adheres to the bark and is up to 3 inches in diameter and 1/10th of an inch thick. But sometimes it may develop in the

form of a stalk crowned by flat or globose white head or it may be undulated and thrown into many folds or it may bend over to form a small bracket. Frequently several such plates fuse together to form a large sheet and irregular crusts may thus be formed. The plate is concentrically furrowed owing to alternate periods of growth and rest. This plate bears the conidia on its surface. The conidia are hyaline, one celled, narrow oval bodies which measure 4-8 μ by 2 to 3 μ.

The colour afterwards changes to black when minute pores appear on the exposed surface of the plate. These pores are the openings of little spherical cavities, the perithecia, which are buried in the plate. The asci are cylindrical about 250 by 10 μ. and contains 8 spores. Paraphyses are present. The spores which measure 27—38 μ by 7—13 μ are opaque black-brown, boat-shaped, unseptate and with obtuse ends. At the same time the plate becomes brittle like charcoal.

The disease spreads from root to root by contact. The fungus does not spread free through the soil. In exceptional cases tea may be infected by spores through dead snags above ground.

Remedies :—The best way to deal with root disease of this kind is to dig out the dead bushes carefully tracing the diseased roots. As a rule all the roots of a dead bush are not equally attacked. The badly attacked ones should be given special attention, as it is frequently possible to trace them to the centre of infection. This is often a piece of a jungle tree. This should be removed. At the same time all the immediate neighbours of the dead bush should be dug out. Some of them will probably be infected so the roots of these should also be examined and the immediate neighbours of any of these bushes found diseased should be removed also. In carrying out these operations special care should be taken to remove all the wood from the soil. This should all be burned. The above procedure sounds very complicated but it is actually very simple and much more effective than surrounding the dead bushes by trenching.

This disease should not be allowed to spread as it sometimes causes the loss of thousands of bushes on a single garden.

Kretzschmaria micropus.

A disease of tea roots similar in nature to *Ustulina zonata* was observed by the writer in 1922, and since then only sixteen specimens have been received.

The general appearance of the roots attacked by this fungus was identical with that produced by *Ustulina zonata.* But unlike *Ustulina zonata,* this fungus produces black rhizomorphs which form globose heads at their ends. Both the fungi have similar spores.

This fungus has not been recorded on tea before. But it has been found by Petch as a wound parasite on *Hevea brasiliensis* in Ceylon. The tea fungus found by the writer was identified by Petch as *Kretzschmaria micropus,* the same fungus which attacks *Hevea brasiliensis* in Ceylon.

Some Mycologists are of opinion that *Kretzschmaria* is a form of *Ustulina.* As Sharples has produced the *Kretzschmaria* form in pure culture from *Ustulina* and also states that the latter sometimes forms rhizomorphs in culture, it may be assumed that this fungus is merely an abnormal form of *Ustulina zonata.*

Sphaerostilbe repens B & Br.

Violet root rot.

Refs :—Bulter, "Fungi and Disease in Plants," p. 432.
Petch, "Diseases of the Tea Bush," p. 146.
Indian Tea Association Pamphlet, "Tea Roots," Part II, 1928.
Indian Tea Association, "Quarterly Journals," 1926, Part II, p. 62 and 1927, Part II, p. 69.

Found in all the tea districts of North East India.

History :—The fungus was named by Berkeley and Broome in "Fungi of Ceylon" in 1875. The fungus was recorded parasitic on rubber in Ceylon in 1907. In 1910 the fungus was described by Petch. It was only in 1917 that the fungus was identified on tea, and has since been found to be one of the commonest diseases of tea in North East India. This fungus is very frequently present in soils in North East India and many jungle tree roots are attacked by it. The roots of the Jack fruit tree are almost invariably attacked. The fungus has also been found on *Albizzia moluccana*.

Description :—On most tea gardens some tea bushes may be found to be fading away for no apparent reason. Year by year they become weaker and weaker until finally they die. In many cases these mysterious deaths occur in patches. Frequently if one of these bushes be dug up it will be found that the roots have a mauve or violet tint and appear to be waterlogged. The roots also in most cases have a peculiar smell something like vinegar. The bark is a violet colour and under the bark thick flat strands of fungus mycelium radiate starwise over the wood. They also penetrate the bark. These strands are usually orange when young later changing to white and finally to black. Black lines are occasionally found in the wood.

The attack usually originates in a stump of a tree—frequently a Jack fruit—and spreads from there through the soil from bush to bush. The thick strands of mycelium are able to grow through the soil like roots. In spite of the presence of the fungus the infected trees do not appear to suffer any serious damage. The fungus is also occasionally found on the roots of vigorous and apparently healthy tea bushes. It would appear therefore that this fungus does not necessarily cause serious damage so long as conditions are otherwise favourable to the infected plants.

There are two kinds of fructifications. They are produced on bark of the collar and exposed portions of roots. The first

form (the conidial form) to appear consists of short red stalks 1/12—1/3 in. long surmounted by a white head. Other fungi produce similar fructifications but they have smooth stalks while those of the fungus in question have hairy ones. The hairiness is lost to some extent with age. The knob at the end is a mass of the hyphae resembling a brush. The spores (conidia) are borne on the ends of the hyphae. The second form of fructification (perithecial form) is produced later. It consists of number of small dark red flask-shaped bodies (perithecia) crowded together at the bases of small stalks or at other places of the stalk whenever the mycelium is exposed. When old these red perithecia become black.

The fungus grows freely in pure culture. Conidia of two kinds are formed in culture. One kind is round, brown, thick walled, and 10 to 12 μ in diameter, the other oval; colourless, thin walled and up to 20 μ long by 10 μ broad. The perithecia are red and contain numerous asci without paraphyses. The asci are irregularly cylindrical with a short stalk. The ascospores are 8 in number in one or two rows. The spore is two celled, constricted at the septum, oval, purplish brown.

On the host each perithecium contains numerous asci with paraphyses. The stalks of the asci are longer and the spores are smaller in size. The size of the asci are 80 x 7.5 μ and that of the spores being up to 15 μ x 5.6 μ.

It was at one time considered that the presence of this fungus was associated with excessive acidity of the soil but later investigations showed that it could also thrive in neutral or even alkaline soils. Changing the acidity of the soil did not therefore have any direct effect on the growth of the fungus. It was noticed, however, that the fungus was most prevalent on badly aerated soils. Soils of such a nature are also bad for the tea bush and in most cases the bushes growing on them are being attacked and damaged by this fungus. The bushes on adjoining, better aerated soil, are also frequently attacked but show no apparent signs of damage.

Remedies :—In the above circumstances it is obvious that the recognised treatment for root disease, *i.e.*, the removal of diseased bushes and their immediate neighbours, is not likely to do much good.

Sterilization of the soil, by the addition of chemical substances, is also impracticable as the fungus is to be found well below the level to which sterilization is likely to be effective. The only reasonable method of treating this disease is by making the tea bush more vigorous and thus better able to withstand the attacks of the fungus.

The improvement of the condition of the tea bush is largely dependant on the improvement of the condition of the soil.

As the fungus is most prevalent on badly aerated soils, improvement in this respect should be the first consideration. Defective drainage should be remedied. The tilth should be improved by taking care to carry out the cultivation when the soil contains the right amount of moisture, and by the addition of organic matter.

The chemical defects of the soil should also be remedied by appropriate manuring with quick acting manures.

Another point of importance is that very poor bushes are unable, by reason of their restricted leaf area, to take immediate advantage of improved condition. It is only through the agency of the leaves that the plant is able to utilise the substances obtainable from the soil. It is desirable therefore, under these circumstances, to apply manures in small doses at frequent intervals. In order to give the plant the opportunity of making the most of the improved soil conditions it is desirable to leave it entirely unplucked for at least one year. Dead and moribund wood may with advantage be removed at the commencement of the treatment.

In spite of the careful nursing some of the bushes will in all probability fail to respond. Such bushes should be removed

at the end of the first year as experience has shown that it is more satisfactory to replace them.

To summarise—

1. Remove all dead and very poor bushes.
2. Improve the mechanical condition of the soil by—
   1. better drainage;
   2. the addition of organic matter;
   3. care in the selection of the times at which cultivation should be carried out.
3. Improve the chemical condition of the soil by the addition of appropriate manures.
4. Allow the poorer bushes to remain unplucked to enable them to take immediate advantage of the improved conditions.

FACTORY REQUIREMENTS FOR THE MAKING OF GOOD TEA.

BY

C. R. HARLER.

Poor tea is frequently made because of insufficient factory space and shortage of machinery. In the rains, owing to the rush of crop, leaf is often underwithered, insufficiently rolled and high fired, in order that the factory schedule may be carried through and space made for the incoming leaf. These unfavourable factory conditions partly account for the falling off in the quality of Monsoon teas from North East India.

It is economically unsound to erect withering space and put down machinery enough to cope with the very biggest rush days of the year. It is a difficult matter, however, to decide exactly what average daily outturn to provide for, but a fair figure may be taken as ¾ per cent. of the total crop. Thus a garden making 10,000 maunds of tea should provide for not less than a daily crop of 75 maunds. On some days as much as 120 maunds or even more may be made, but this is exceptional and, if it occurs many times in the season, points to irregular plucking.

Accepting an average daily outturn of 75 maunds, it will be seen that in four months, each of 26 working days of average maximum crop, 7,800 maunds will be manufactured, leaving 2,200 maunds for April, May and the first part of the June and the back-end from mid-October. This is a reasonable and common crop distribution in North East India.

In calculating factory requirements allowance is made for average weather conditions, when a sufficient wither can be obtained in about 18 hours. On some days it is impossible to obtain a suitable wither and practically every season there are one or two wet, cloudy spells lasting a week or ten days, during

which the leaf hardly withers at all. In some gardens allowance is made for such periods in the form of extra withering space and firing machinery. Thus the factory requirements here outlined fall far below those actually available in many of the best gardens of Upper Assam, although they are greater than those of the average tea factory in North East India.

Withering space.

When tea leaf is withered three main factors are concerned in bringing it to the condition in which it is suited to rolling and fermentation. These factors are :—

time,
temperature,
amount of drying.

The degree of influence of each factor is not known, but in bringing the leaf to the required state it seems that, within limits, all three factors are working in a similar direction. It is common experience that the alteration of one factor necessitates a change in one or both the others in order to obtain results similar to those shown under the first set of conditions. Thus an increase in temperature necessitates a decrease in the withering time or the amount of drying or both.

The degree of freedom in the variation of each factor is limited. Experience has shown that the time of withering may not be reduced much below 12 hours nor increased much beyond 24 hours. Very slow withering may produce sour teas and very quick withering usually produces "raw," thin teas.

The temperature at which the leaf is withered should not rise above 90° F., if it does, "raw," thin teas may result. The lower limit of temperature has not been fixed and is not a question of practical importance at present. Some of the best teas in North East India are made when the minimum falls below 50° F. The average temperature, however, can certainly be too low and in parts of China and Japan the non-success of black tea manufacture is probably due to the fact that

leaf cannot be withered suitably within a reasonable period of time. The Chinese sometimes use hot air when the ordinary temperatures are too low for withering.

Leaf may be dried too much and experience shows that about 54% moisture is the lower limit for drying. The upper limit has not been fixed so definitely. Leaf containing 70% moisture and more is not flaccid enough for successful rolling, and is mashed rather than rolled.

In North East India, the average daily temperature during the Monsoon period is about 83° F. So far as the time taken for the wither is concerned, about 18 hours is found to be the most convenient. With these two factors thus loosely fixed there remains the degree of drying to be decided upon. Experience has shown that with an average temperature of about 83° F. the leaf is ready for rolling in about 18 hours if 100 lbs. have dried to about 65 or 70 lbs. Leaf dried to this extent contains about 65% moisture. At average temperatures lower than about 83° F., a fuller degree of wither is necessary.

In order to obtain the necessary degree of drying, it is generally necessary to spread leaf at a thickness of about 1 lb. to 9 sq. ft. The spreading may be somewhat thicker on wire racks and thinner on hessian or chungs. At the thickness of spreading mentioned, a factory making a crop of 10,000 maunds tea should be supplied with 2,16,000 sq. ft. of withering space or about 22 sq. ft. of space per maund of tea made in the season.

In Upper Assam much larger areas than this are usually provided and the withering space on many gardens is more than 30 sq. ft. per maund of tea made in the season.

The withering space required will not only vary with the type of rack, wire or hessian, but also with the position of the leaf house and its width. An airy situation should be chosen for the withering sheds and the individual houses should not be more than about 50 feet wide.

Withering lofts.

A natural wither under favourable conditions is preferable to the wither usually obtained in a loft. A good natural wither postulates an unlimited supply of cool, moderately dry air so that the leaf may be dried steadily and evenly. With loft withering the air is generally warmed to enhance its drying capacity and the drying is usually quicker and less even than with a natural wither.

In the Dooars and Darjeeling, withering lofts have been in general use for many years and several modern lofts are now being erected in Assam and the Dooars. The latter are constructed on the lines followed in Ceylon, South India and Java, in which places loft withering is general.

Two essentials in a withering loft are air-tightness and sufficient fan strength to move the air at a suitable rate. In the Dooars, the lofts are frequently not air tight, with the result that the fans draw in air by the easiest channel and the flow across the centre racks of the loft is very small. Under these conditions the leaf merely stews in a warm atmosphere. Through air flow across the leaf is often also reduced by steeply sloping racks which deflect the air current to the ceiling of the loft.

Another drawback to the Dooars lofts is the great heat often developed in them and, on more than one occasion, temperatures of 110° F. have been registered. As the maximum for the loft temperatures, 90° F. may be taken as a first approximation.

In Ceylon, where loft withering is a highly developed practice, the warm air is taken from the firing room, centrally situated, and drawn into a bulking chamber running from the first floor of the factory right to the roof. From this chamber are several series of doors, each series leading to the lofts situated to the left and right of the bulking chamber. With two stories, there are thus four lofts, with three stories, six.

The air is drawn through the lofts by means of two sets of suction fans situated in exhaust chambers at each end of the factory. By the arrangement of doors two sets of fans are sufficient to deal with four or six lofts in turn. In some factories, boosting fans are placed between the firing room and the bulking chamber, giving increased control over the air flow. The need for boosting fans is becoming increasingly evident. The sides of the lofts are practically filled with windows so that on suitable days these may be opened and a natural wither obtained.

Experience and experiment in Ceylon (1) have shown that the air is in a suitable state regarding humidity if it enters the loft with a difference of 7 or 8° F. between the wet and dry bulb readings. Results obtained in Ceylon must, however, be applied with caution to lofts in North East India where working temperatures are considerably higher than those in Ceylon. The whole problem of loft construction and management is a subject for extensive experiment.

It has been observed that the drying of the leaf should take place as soon after plucking as possible but that it should not be unduly hurried, and a minimum period of about 6 hours should be given to this process. When the requisite degree of drying is realised, the loft should then be disconnected from the warm air system and a wait made for the leaf to take on a state suitable for rolling and fermentation. During the period of waiting, slight further loss in the moisture content of the leaf will take place, partly owing to leaf transpiration.

Rolling.

It is almost as important to keep the rolling room cool as it is the fermenting room. The limited control of the condition of the factory atmosphere has led to the practice of fermenting in a room away from the factory. With the installa-

(1) An Account of Ceylon Withering Methods is given by Elliot, E. C. and F. J. Whitehead. "Tea Planting in Ceylon," published by Times of Ceylon Co. Ld., Colombo, price Rs. 20/-.

tion of pressure humidification systems, which give a very full degree of control of atmospheric conditions, the need for the separation of the rolling and fermenting rooms ceases. If rolling and fermentation are caried out in the same room much labour is saved and fuller supervision is possible. The temperature of the rolling room should not be above 80° F.

In estimating the amount of rolling machinery necessary, account must be taken of the length of the roll and, as a basis for calculation, a roll of one and a half hours, with the rollers making 60 revolutions per minute, is considered.

The rolling programme varies, of course, with the type of tea which the garden aims at producing. The average garden, making a medium or good tea, should roll first lightly, with no pressure, for 20 minutes or half an hour. After sifting, the coarse leaf should be rolled hard for an hour. All the rolling should be done before fermentation.

In order to avoid excessive heating during the rolling of the coarse leaf, the pressure cap must be raised and lowered alternately and a green sift should be given in the middle of the heavy roll, if possible. The fact that the raising and lowering of the pressure cap entails considerable effort on the part of the operator often leads to the neglect of this process unless supervision is strict. In view of this and of the importance of the application of pressure during rolling, attention to and trial of the automatic pressure caps now being fitted to rollers is worthy of notice. By means of these fitments, the power needed for raising and lowering the pressure cap is supplied off the roller itself. Self-recording diagrams showing the pressure periods can also be fitted to rollers.

According to the maker's specification, and to actual practice, a big "Metallic" roller will take a charge of about 360 lbs. and a "Rapid" 32 inch roller will take about 300 lbs. leaf. The possible charge varies with the length of time leaf is fed into the roller after the latter starts revolving.

In the rains, leaf suitably withered contains about 65% moisture, so that 4½ maunds withered leaf (an average "Metallic" roller charge) will make about 1½ maunds tea. An hour and a half's rolling will occupy a period of about 2 hours, counting time for charging, discharging, cleaning, etc., hence the roller can deal with leaf at the rate corresponding to about ¾ maund finished tea per hour. With an 8-hour rolling day one rolling table can thus deal with leaf making 6 maunds tea.

In a season, one table working for 1,200 hours can deal with 900 maunds tea. With less loss of time in charging and discharging or with a greater speed of rolling, one roller can be made to deal with 1,000 maunds tea or even more. However no factory should be less liberally machined than on the reckoning of one roller per 1,000 maunds tea made.

A "Rapid" 32-inch roller can easily deal with the coarse leaf from a "Metallic" roller since, with plucking consisting of two leaves and a bud, the coarse leaf should be about 70% of the original charge. With coarser plucking the fine leaf should only be about 20% of the original charge.

Fermentation.

Factories are often short of fermenting space. No very exact figures can be given, but with leaf spread 2 inches thick, a space of about 6,000 sq. ft. is conveniently large enough for a 10,000 maunds crop.

Now that the installation of humidifying systems is becoming common, some indication regarding the number of units necessary should be given. With Vortex Humidifiers installed at a height of about 12 feet, it has been observed that about 12 humidifiers can cope with the average fermenting room dealing with 10,000 maunds tea in a season. With this number of units it is practically always possible to raise the humidity of the air to 95% (difference between wet and dry bulbs about 1° F.).

Tea "fermentation" is not a true fermentation, but a process consisting essentially of the oxidation of part of the tea tannin to red products. For the best development of the pro-

cess a liberal supply of cool, humid, fresh air is necessary and, on this account, humidifiers should be fitted with air ducts. Each humidifier is capable of drawing in as much as 1,000 cub. ft. of air per minute and by this means the air in the fermenting room is kept fresh.

Firing machines.

The capacity of firing machines given by the makers usually refers to working temperatures of 210° to 230° F. During the last few years the general tendency has been towards lower firing temperatures, and 180° F. is usually aimed at, which temperature gives the most satisfactory results so far as the quality of the tea is concerned. Partly in order to compensate for the reduced capacity due to firing at lower temperatures, fan speeds have been raised. The net result of these changes is generally a drying capacity somewhat lower than that possible at the former higher temperatures and slower fan speeds.

As the fan speed varies, so the volume of the air passing through the machine varies, but the air pressure varies as the square of the fan speed. Experience has shown that the drying capacity of a machine varies almost as the square of the fan speed. Within small limits it is safe to increase the fan speed above that scheduled by the makers.

With a fan speed of 400 revolutions per minute and an initial temperature of 220° to 230° F., a big "Empire" machine will dry 20 maunds withered leaf (66% moisture) to 10 maunds of 12-anna leaf (30% moisture) per hour. At 180° F., the output is reduced to about 7 maunds 12-anna leaf per hour. If, however, the fan speed is raised from 400 to 450 revolutions per minute, then the outturn at 180° F., is about 8¾ maunds per hour. This amounts to about 6 maunds finished tea per hour. In a season of 1,200 working hours a big "Empire," assisted by a suitable finishing machine, can thus deal with about 7,200 maunds tea. Using the higher temperature and lower fan speed the capacity for the season would be 8,000 maunds tea.

These capacities are however based on the assumption that the withered leaf contains 66% moisture. With a lighter wither the outturn is proportionately reduced. Thus, working at the maker's temperature and fan speed the output of a big "Empire" is 800 lbs. 12-anna leaf per hour if the withered leaf contains 66% moisture. This leaf makes about 565 lbs. dried tea. If the withered leaf contains 70% moisture the hourly output is reduced to 602 lbs. 12-anna leaf (about 445 lbs. dried tea) per hour. If the leaf is unwithered and contains about 75% moisture the output is reduced to 450 lbs. 12-anna leaf (about 330 lbs. dried tea) per hour.

Working with average leaf throughout the season at a temperature of 180° F., and a fan speed of 450 revolutions per minute an output of not more than about 6,000 maunds can be expected from a big "Empire" assisted by a suitable finishing machine.

A big E. C. P. machine with the temperature reduced to 180° F., and the fan speed increased from 320, the scheduled speed, to 370 revolutions per minute, is capable of an hourly output of about 6¾ maunds of 12-anna leaf. This equals about 4¾ maunds finished tea. In a season of 1,200 working hours, an E. C. P., with suitable finishing machinery, can thus deal with about 5,700 maunds tea. Here again leaf withered to 66% moisture is assumed. Working with average leaf throughout the season, an E. C. P. can deal with about 4,700 maunds tea, drying it to 12-annas.

In order to make the best tea, not only should the firing temperature be low, but the spreading should be thin, about ¼ inch, in order that the hot air may pass freely through the machine. When the progress of the air is seriously impeded, "stewing" of the leaf takes place, flat teas are made and quality is lost. With the thin spreading mentioned the output will be less than that indicated in the calculations above.

The ratio of the capacity of the second firing machine to the first should be about 2 to 5. Under good rains conditions

the first firing reduces the moisture content of the leaf from about 66% to 30% (*i.e.*, 12-anna) and the second firing reduces it from 30% to about 3%. This means that 20 maunds withered leaf are dried to 10 maunds in the first fire and to 6¼ maunds finished tea in the second fire or, in another way, 10 maunds water are removed in the first fire and 3¾ maunds in the second.

A 10 ft. "Imperial Venetian" will keep pace with a big "Empire" for the second fire as will a "Double Tilting Tray" with a big E. C. P. Under no circumstances should the temperature of the second firing machine be raised above 180° F.

Sorting.

Sorting is so far from being standarised that little can be said on the subject of factory requirements. The big mechanical sorters at present on the market can deal with 80 to 100 maunds tea a day.

The value of ample space and dry floors in the sorting room is obvious. The atmosphere of the sorting room should be maintained at a relative humidity of 65% if possible, for with the air in this condition the tea will automatically assume a moisture content of about 6% during sorting. Tea should be packed containing 6% moisture.

Power.

Most of the power in a tea factory is required for rollers. A "Rapid" or a "Metallic" running empty takes about 1¾ B. H. P. and running with leaf at ordinary light pressure from 4 to 5 B. H. P. With heavy pressure the power required may be as much as 12 B. H. P.

A big "Empire" requires about 6 B. H. P. and a big E. C. P. about 5 B. H. P.

In a 10,000 maunds factory, equipped with the minimum of 10 rollers and suitable firing machinery a peak load of about 140 B. H. P. may be reckoned, including power for sorting machines, packers, fans, dynamo, *etc.* It is not likely that more than 5 or 6 rollers will be working at maximum pressure at the same time, hence the actual power needed at any time will be not more than about 80 or 90 B. H. P.

NOTES ON BAMBOOS.

BY

C. J. HARRISON.

Bamboo finds extensive use on tea gardens for fencing, building, bridges and in many other equally important ways, so that a few notes describing briefly the botany, distribution and cultivation of the more generally known kinds may be of interest and of use to tea planters.

Bamboos belong to the sub-order *Bambuseae,* a section of the great natural order of the grasses (*Gramineae*). *Bambuseae* are divided into 23 genera, of which 15 belong to the Indo-Malayan region, the remaining 8 being chiefly American. The 15 Indian genera comprise 115 species of bamboos but many of these are either rare or else entirely useless for any practical purpose.

The distribution of bamboos depends on climate, and it is only tropical and sub-tropical regions which favour natural growth. In Europe there are no natural growing species.

The stems or "culms" of all bamboos are more or less cylindrical, almost always hollow, and separated by partitions which are called nodes (Assamese—gathi), the intervening spaces being termed the internodes (Assamese—pab). These latter vary considerably in length, the longest being about 50 inches. Those types of bamboo having long internodes are more suitable for fences, wicker and all kinds of interwoven work, while for building and posts, bamboo with short internodes is more suitable on account of its rigidity. The thickness of the stem-wood of course determines the suitability or otherwise of the bamboo for building.

The height and diameter of bamboos varies between 100 to 120 ft. in the "wabo" (*Dendrocalamus giganteus*), having a culm diameter of up to 12 inches; and, in the case of the

arundinaria densifolia a height of 3 ft. only, and culm diameter of ⅓ inch. Bamboo culms grow at a rapid rate, the larger types often reaching a height of about 50 ft. in a month.

The bamboo culms arise from rhizomes, or underground stems, to which are attached the roots proper. In nearly all species of Indian bamboo, these rhizomes are massed together in a thick knotted clump, from which the stems arise, but in some species, as for example the "muli" bamboo (*Melocanna bambusoides*), the rhizomes push their way underground sending out rootlets and stems singly at intervals. This latter type of bamboo is often responsible for the incredibly rapid covering of a hill side with bamboo.

The stems or culms as they grow, throw out sheaths at each node. The sheaths which are green at first and covered with black hairs, gradually turn brown and fall off. As these sheaths are shed in the second year of growth, side shoots develop from the nodes and bear the true bamboo foliage. Most bamboos bear culm-sheaths which are, in shape, size and texture, characteristic of the particular species. The leaves of all species of bamboo are generally very similar and are of little use in distinguishing various species.

Very few species of bamboo flower annually, while in most cases flowering seasons come at very long intervals, when the whole of one species in a district may flower at the same time and die down after giving seed. Even those species, like the giant "wabo," which may also flower sporadically, give at such times only a small quantity of poor seed while the general flowering will give a large quantity of very good seed.

Owing to this very infrequent flowering, our knowledge of many species is incomplete, since their flowers and fruit are as yet unknown.

Distribution. Of the seven principal physiographical regions of India and the Malay Peninsula, almost the whole of the tea districts of North East India lie in region No. 5

(Gamble), *i.e.*, Bengal, North East Himalaya and Assam. In this region the most characteristic bamboos are the kokwa (*Dendrocalamus Hamiltonii*) in the north, jati (*Bambusa tulda*) in the middle region, and the muli (*Melocanna bambusoides*) in the South. Besides these three indigenous species there are 46 other species which have become acclimatised.

The types of bamboo which have become well known in connection with the tea industry are as follows :—

1. *Bambusa tulda.* Local names :—jati, deobans, nalbans and jao (Assam), mirtenga (Surma Valley), jowa, tulda (Bengal) matela and kiranti (West Dooars). This species is 20 to 70 ft. in height having stems 2 to 4 inches in diameter with fairly thin walls, ¼ to ½ inch thick. It is the ordinary bamboo used for fences and roofs and, on account of the fact that the nodes are fairly wide apart, is very pliable when split up, and is used for all kinds of interwoven work.

2. *Bambusa balcooa.* Local names :—bholoka (Assam), balku-bans (Bengal), boro-bans (West Dooars). This is probably the most useful bamboo in India and grows to a height of 50 to 70 ft. with wide and thick stems, 3 to 6 inches in diamater and up to 1 inch thick. Its nodes are generally much closer together than is the case with the abovementioned species and it is on this account invaluable for building posts, scaffolding and bullock carts. A thinner variety of this species is called in Assam the bhaluki-bans (female bamboo), the thicker variety being regarded as the male bamboo. Some specimens of balukibans have however been identified as *Bambusa teres*.

3. *Melocanna bambusoides.* Local names :—muli (Bengal and Surma Valley), tarai (Assam) and often referred to as the terai bamboo.

The roots do not bunch together but spread out under the ground throwing out stems at intervals. This species is common on teelas in the Surma Valley.

It grows to a height of up to 60 ft., has a stem diameter of 2 to 3 inches but is very thin walled, $\frac{1}{5}$ to $\frac{1}{3}$ inch thick. It is used extensively for walls and thatch roofing and is generally stated to be unattacked by white ants. Its nodes are up to 20 inches apart and are not so prominent as in most other species.

4. *Dendrocalamus Hamiltonii.* Local names :—chye (Dehra Dun), kaka or kakwa (Assam and Bengal). This is a tall bamboo reaching 70 ft. or more in height, and 4 to 6 inches in diameter, with fairly thin walls ($\frac{1}{2}$ to $\frac{3}{4}$ inch thick). It is common in Darjeeling, Terai, Dooars and Assam, but not well known in the more southerly regions.

Its softness and thin walls make it less useful for building than the bholuka and jati but it is used to a great extent in basket and mat work. *D. Sikkimensis* and *D. Hookeri* are very similar bamboos and are often confused with the kakwa. The first-mentioned is used in the Darjeeling district for making vessels for carrying water and milk.

5. *Dendrocalamus giganteus.* Local names :—worra Assam), wabo (Naga Hills and Burma). This is the giant of the bamboo tribe, specimens often reaching 100 ft. in height and 8 to 12 inches diameter, with thin walls covered with a white waxy scurf when young.

It is sometimes confused with other similar species such as the *D. brandisii* and *flagellifer.* It is often used for making vessels and water pots, particularly in the Naga Hills.

6. *D. Mastersii.* Local name :—bheti-bans (Assam). A small reed-like bamboo with a solid stem $\frac{1}{2}$ to $\frac{3}{4}$ inch diameter used for making sticks, umbrella handles, etc.

Other bamboos in use are the *Bambusa pallida,* (mokal, khora, bijli in Assam; bakhal in Surma Valley; pushee and bonshing in Darjeeling), 40 to 60 ft. high, with stems 2 to 3 inches diameter, with thin walls, and is used for fencing and basket making. The *Bambusa nutans* bears the same Assamese local

name but is rather larger. It is used for the same work as the *B. pallida*. Another valuable bamboo in Assam is the bajal (*Pseudostachyum polymorphum*), a long thin bamboo only an inch in diameter and very thin walled. It is used for basket work in tea gardens and for mats. There is also the kanta-bans, kota or kata (*Bambusa arundinacea*), a "jungle" species, having long spikes projecting from the nodes, and is therefore difficult to cut, but makes a good fence. It grows high and thick culms, which are however crooked and knotty and unsuitable for general uses.

Arundinaria Griffithiana and *A. callosa* also bear spikelets, and the local names kanta-bans, kata, kota may also be applied to these species.

Since one local name is often found applied to several different species of bamboo having similar appearance and practical application, it is impossible in all cases to apply definite local names to definite species.

Propagation. There are four methods of propagating bamboos of which two, namely, from seed and from off-shoots, are of importance.

As mentioned previously, seed from a general periodic flowering is best for propagation, seed from a sporadic flowering being often weak or sterile. The seed is encased in several layers of husk and is actually very small in size in most species. When planted fresh it germinates in two to three weeks. The seed should be put out in a nursery of rich moist soil, about 12 inches apart and when the plants have come through, the use of thatch as shade, spread on chungs 3 to 5 ft. from the ground is desirable.

After two years the plants may be transferred to the bamboo plantation, the planting being at intervals of 20 ft. with a liberal supply of cattle manure.

In propagating bamboo from off shoots of the older parent bamboo clump, care should be taken to use only one year to 18

months old off-shoots. These should be selected from the *outer ring* and cut at 8 to 10 feet from the ground just above a node. The soil is carefully removed round the roots and the main root or rhizome cut away from the parent stock, leaving as much root as possible with the off shoot. Care should be taken to do as little damage as possible to the rootlets. The off-shoots are then immediately planted out in the new clearance 20 ft. apart in pits containing a mixture of soil and manure in equal quantities. The root should be buried so that one node of the stem is just below ground, and the soil should be firmly embedded round the plant. The stem should point north at an angle of 45° to the ground. This lessens the drying effect of the sun on the stem, and if the top is covered with a cake of cattle manure the drying effect of the sun on the open cut is lessened still more. If a stem dries up it may split and die right down the root and the plant may fail to grow, or at least may come away very slowly.

In most common bamboos, the stem sheaths attached to the nodes of young stems are green and are covered with black hairs. The sheaths turn brown after one year and fall off. It is therefore easy, by selecting stems which bear brown sheaths on the lower nodes, to make sure of using off-shoots not more than 18 months old for propagation. The most suitable time for planting is in March and April.

The advantages of off-shoot propagation over seed propagation are firstly, that yielding clumps are obtained a few years earlier and secondly, that the cost of propagation is less, as no nurseries have to be prepared. The chief disadvantage lies in the fact that the parent bamboo may be near its general flowering period, *i.e.*, its death, at which time all the bamboos propagated from its off-shoots will flower and die. In the case of seed propagated bamboo, a long period can be guaranteed before a general flowering will take place.

Two other methods of propagation are by layering and by cuttings. In the former case, a stem is bent over from the

clump and a portion pegged under the ground. When roots develop at a node on the portion below the ground, the stem may be cut from the parent and the excised piece may be removed and planted elsewhere, care being taken not to damage the newly formed roots. This is a tedious and not very successful method. Propagation by cuttings is similar to the method of using off-shoots, except that no care is taken to see that a portion of the roots is removed with the stem, the lowest node being relied on to throw out roots when placed in the ground. This method results in a large percentage of failures and though rapid and easy is not recommended.

Maintenance of Bamboo Plantations. Bamboos grow well on any soil which is suitable for tea, *i.e.*, a well drained fairly rich soil. The common useful types will not grow on land having a tendency to water-logging. The peculiar formation of land known as Korkani, in which the soil is cut up by irregular ditches and holes, is very suitable for bamboo. Tea suffers from close proximity to bamboos, which should be at least 15 ft. from the nearest tea bush.

Cattle manure is a valuable manure to apply to a bamboo clump in the early stages of its development. Since they are very adversely affected by growth of jungle, the young plants and off-shoots should be clean weeded regularly till they become large enough to keep the jungle down themselves by virtue of their shade.

A bamboo stem is ripe for cutting after it has had two years growth and should not be left uncut after three years. If taken younger than two years, the wood is soft and does not respond to treatment commonly employed for hardening. For permanent work such as building and carts, bamboo should be soaked for a month in water in order to harden the stems. It is generally considered that the muddy water in an adjoining "hoolah" is most suitable for this purpose. Care should be taken not to allow continual cutting of the outside stems of the clumps thereby leaving the inner ones to form a thick mass

which is difficult to deal with. Bamboo stems should be cut out of the clump so as to leave the younger stems evenly spaced out. One clump should give under reasonable care in treatment, an annual yield of up to 20 bamboo stems.

The ordinary cooly knife is unsuitable for cutting bamboos and a good instrument can be made from a piece of steel 1 ft. long 2 inches broad and ¾ inch thick, flattened to 3 inches wide at one end and sharpened like a chisel. This implement is driven into the side of the stem and used like a crowbar.

The very young bamboo shoots are edible, especially when boiled, but their removal from the clump, apart from the loss of future bamboos entailed, is itself harmful.

Pests and Diseases. There is a species of rat which eats the shoots of bamboos and unless destroyed along with its nest, which is found in the middle of the clump, can cause much damage to a bamboo plantation. Hares also at times eat the young bamboo shoots.

Bamboos do not seem to suffer much from insect pests or diseases, though there is one insect, the grub of which feeds on the roots of bamboo clumps causing them to die out.

Uses and Products of Bamboo. The main uses of bamboo are so widely known and so numerous that it would be unnecessary and tedious to deal in detail with them here. For tea garden work, bamboo finds application in building, fencing, bridges, revetment of drains and for making posts, for support for nursery shade and for plucking baskets.

Attempts in the latter part of the nineteenth century to employ bamboo for paper making were frustrated by economic and practical difficulties. Otherwise there is no doubt that the bamboo is capable of yielding a "paper stock" of the highest quality.

The bamboo seed forms a highly nutritious food stuff and has in time of famine saved thousands of lives. It contains

water 13.5 per cent.; proteins 10.8 per cent.; starch 71.6 per cent.; oil 0.6 per cent.; fibre 2.1 per cent. and ash 1.4 per cent.; of this ash 90 per cent. is silica.

Bamboo shoots are edible and form the principal constituent of Chinese "Chow-Chow."

The leaves of bamboo are valuable as fodder and as a cure for cold in horses and cattle.

The average of several analyses of the stem wood of jati bamboo, gave a moisture content of 25.5 per cent. in the case of the green stem, and of 16.3 per cent. in the case of sun-dried stem.

The percentage of ash, calculated on dry matter is 1.80 per cent. and of this 50.6 per cent. is silica. Thus, the dry wood contains 0.91 per cent. of silica.

The wood fibre is very long and closely packed, a fact which accounts for the rigidity and toughness of a bamboo.

A rough estimate of the consumption of bamboos in India places the latter at about 200 million stems annually, and bamboo forms the most important portion of the minor forest produce of all forest divisions in India.

In the appendix the truly representative species of bamboo to be found in the North Eastern Himalaya, Assam and Bengal region are given, together with as many as possible local names. The average height, stem diameter and thickness have been given where possible. This information has been obtained mainly from Gamble's Bamboos of British India.

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APPENDIX.

Region.	Botanical Names.	Approx. height, diam., thickness.	VERNACULAR NAMES.			
			Assam.	Surma Valley.	Bengal & Dooars.	Darjeeling, Sikkim and Bhutan.
Plains of Lower Bengal and Valleys	Bambusa tulda	50′/3½″/½″	jati, nalbans, jao, ghora, bijuli, deobans	mirtenga, metenga.	tulda jowa, peka, kiranti and metela.	.....
	Bambusa Balcooa	65′/5″/1″	baluka	silbarua, telibarua.	balku bans, boro bans.	.....
	Bambusa arundinacea	70′/6″/1″	kotoha, katta ...	ketua. katausi	behor bans, kanta bans.	.....
North East Himalaya, Sikkim and Bhutan— (1) Lower Hills and Terai.	Dendrocalamus Hamiltonii	60′/6″/½″	kaka, kokwa	.....	Chye pecha	.....
(2) Up to 4,000 ft. level.	Bambusa nutans	40′/2½″/⅓″	bidhuli mukhial, sering jai (Khasi).	peechle wa-malang (Kuki)	.....	mahlo (Sikkim).
	Dendrocalamus sikkimensis	55′/6″/1″	wadah (Garo) ...	.....	.....	pugriang (Lapcha).
	Arundinaria intermedia	10′/½″/$\frac{1}{10}$″	.....	.....	.....	nigala (Nepal). paroniok (Lepcha).
(3) 4,000–6,000ft. level.	Cephalostachyum capitatum	20′/1″/⅕″	sillea (Khasi)	.....	.....	gobia (Nepal) payong (Lepcha).
	Pseudostachyum polymorphum.	40′/1″/⅕″	bajal, tolli, nal	.....	.....	.....
	Arundinaria Hookeriana	20′/1″/$\frac{1}{10}$″	.....	.....	.....	singhanj (Nepal). prong (Lepcha).
	Teinostachyum Dullooa	30′/2⅛″/⅛″	dulloa	dolu	.....	pogslo, tokre.
	Dendrocalamus patellaris	25′/1″/⅕″	.....	.....	.....	pagjrok.

APPENDIX (*contd.*).

Region.	Botanical Names.	Approx. height, diam., thickness.	VERNACULAR NAMES. Assam.	Surma Valley.	Bengal & Dooars.	Darjeeling, Sikkim and Bhutan.
(4) 6,000–9,000ft. level.	Arundinaria racemosa	10′/1″/$\frac{1}{5}$″	.....	.....	.....	pheong (Bhutia). pummoon (Sikkim). maling (Nepal). phyeum (Lepcha).
(5) Above 8,000ft. level.	A small variety of the above and	5′/$\frac{3}{4}$″/$\frac{1}{10}$″	.....	.....	.....	mheem (Bhutia). miknu (Lepcha).
	Arundinaria aristata	10′/$\frac{1}{2}$″/$\frac{1}{10}$″	.....	.....	.....	pathioo (Nepal). bheban (Lepcha and Bhutia).
	Arundinaria Falconeri .. .	15′/$\frac{3}{4}$″/$\frac{1}{10}$″	.....	.....	.....	pummoon, paomung (Lepcha).
Assam, Khasia and Jaintia Hills and Naga Hills.	Bambusa tulda	50′/3$\frac{1}{2}$″/$\frac{1}{3}$″	as above	.....	.....	.....
	Bambusa nutans ..	40′/2$\frac{1}{2}$″/$\frac{1}{4}$″	bidhuli, mukial sering jai (Khasi.)	peechle wa-ma-lang (Kuki).	.....	mahlo (Sikkim).
	Bambusa teres	50′/3″/$\frac{1}{3}$″	baluki makhal	.....	.....	.....
	Bambusa pallida	50′2$\frac{1}{4}$″/$\frac{1}{3}$″	makhal, bijli, jowa, usken (Khasi).	burwal bakhal	.....	pushee bonshing.
	Bambusa Mastersii	25′/$\frac{3}{4}$″/$\frac{3}{8}$″	bheti-bans	.....	.....	.....
	Bambusa khasiana	35′/1″/$\frac{1}{4}$″	tomar, serim (Khasi)	wa chiusa (Cachari).	.....	.....
(1) Low country	Bambusa Balcooa	65′/5″/1″	as above	.....	.....	.....
	Gigantochloa macrostachya	40′/3″/$\frac{1}{5}$″	tekserah (Garo)	madi	.....	.....
	Dendrocalamus Hookeri -	55′/5″/1″	seiat, sijong, denga	.....	.....	patu, tili bans.
	Dendrocalamus Hamiltonii.....	60′/6″/$\frac{1}{2}$″	kaka, kokwa	.....	chye, pecha	.....
	Dendrocalamus longispathus	50′/3$\frac{1}{2}$″/$\frac{1}{2}$″	.....	.....	khang	.....
	Pseudostachyum polymorphum.	40′/1″/$\frac{1}{3}$″	bajal, tolli, nal	.....	.....	filing, paphok.
	Teinostachyum Dullooa	30′/2$\frac{1}{2}$″/$\frac{1}{3}$″	dulloa	dolu	.....	pogslo, tokre.
	Teinostachyum Griffithii	35′/$\frac{3}{4}$″/$\frac{1}{5}$″	beti	.....	.....	rivett.
	Melocanna bambusoides	50′/2″/$\frac{1}{3}$″	tarai	muli, wati, pagu-tulla.	muli, paia	.....

(2) Hills	Arundinaria Elegans	15′/¾″/$\frac{1}{10}$″	jilli (Naga)			
	,, polystachya	shrub				
	,, Griffithiana	20′/1″/⅛″	khanp uspar (Khasi)			
	,, callosa	15′/¾″/⅛″	uspar, uskong (Khasi)			
	,, khasiana	10′/½″/$\frac{1}{10}$″	namlang (Khasi)			
	,, hirsuta	5′/$\frac{1}{5}$″/$\frac{1}{10}$″	ustoh (Khasi)			
	,, suberecta	10′/⅓″/⅛″	ukadai namlang (Khasi)			
	,, Prainii	20′/$\frac{1}{3}$″/⅛″	lombnang sampi, khevva (Naga)			
	,, Mannii	25′/½″/¼″	beneng (Khasi)			
	,, Rolloana	8′/$\frac{1}{2}$″/$\frac{1}{10}$″	jipvo (Naga)			
	Phyllostachys bambusoides	10′/$\frac{1}{2}$″/$\frac{1}{8}$″	deo, bih			
	Teinostachyum Helferi	25′/½″/$\frac{1}{10}$″	wali (Garo)			
			tumo (Khasi).			
	Cephalostachyum capitatum	20′/1″/¼″	siilea (Khasi)			gobia, payong.
	Cephalostachyum pergracile	35′/2″/⅕″	lating (Naga)			
	Dendrocalamus giganteus	80′/10″/$\frac{2}{3}$″	worra, Wabo			
(Garo Hills)	Dendrocalamus sikkimensis	55′/6″/1″	wadah (Garo)			
Sylhet	Bambusa polymorphum	40′/1″/$\frac{1}{5}$″		betua	jama betua	
	Melocalamus compactiflorus	25′/½″/$\frac{1}{10}$″		deral, lota		
Chittagong and its Hill Tracts—						
(1) Low Hills (teelas)	Melocanna bambusoides	50′/2″/¼″	tarai	muli, wati pagu-tulla	pia, muli	
(2) Valleys and Forests	Bambusa Tulda	50′/3½″/⅓″	as above			
	Teinostachyum Dullooa	30′/2½″/1″	dulloa	dolu		pogslo, tokre.
	Gigantochloa macrostachya	40′/3″/⅕″	tekserah (Garo Hills)	madi		
	Dendrocalamus longispathus	50′/3½″/½″			khang	
	Melocalamus compactiflorus	25′/¼″/$\frac{1}{10}$″		daral, lota		
	Dinochloa McClellandi	80′/2″/⅓″				

METEOROLOGICAL OBSERVATIONS IN NORTH EAST INDIA, 1928.

BY

C. R. HARLER.

The 1928 season in North East India.

The 1928 season in Assam and the Dooars has been generally characterised by the following conditions :—

(*a*) a severe early drought.
(*b*) light rainfall in July.
(*c*) very late rains in October.

In many districts the early drought was considered to be the worst within memory so far as tea was concerned. Some districts in Upper Assam did not suffer badly because of a very wet week in March.

The light rainfall in July was general from the Terai to Dibrugarh. At Tocklai less than 3 inches of rain was recorded between July 14th and the end of the month. The comparative dryness at this time of the year was a benefit rather than otherwise.

The rains continued till the last day of October, in which month there were 20 wet days at Tocklai and a total rainfall of 7.43 inches.

On account of these departures from the average season, it has been suggested that the climate of Assam is changing and that the seasons are now different, on the whole, from what they were 30 years ago. In 1907, Mann (1), at that time dealing with similar statements regarding changing climate which were then being made by an earlier generation of planters, gave rainfall figures for various tea districts showing that there had been no appreciable change in the total annual rainfall and the rainfall during each of the months of February, March, April

(1) Mann, H.H., The Tea Soils of North East India and their Treatment. *Indian Tea Assoc.*, Calcutta, 1907 (p. 8).

and May during the decades ending 1870, 1880, 1890 and 1900. The records for Dibrugarh, Tezpur, Silchar, Chittagong and Darjeeling were studied in this connection.

Since Mann's observations a further 20 years' rainfall records are available, and the figures given by the Government recording stations (2) may be compared with those given for 1900. The table below gives the total annual rainfall averages for certain stations in the tea districts of North East India. The 1920 averages include records taken prior to 1900.

Annual Rainfall at certain Stations in North East India.

Station.	Average up to 1900.	Average up to 1920.	Change.
Dibrugarh	112·11 ins.	111·86 ins.	—0·25 ins.
Sibsagar	94·35 ,,	95·55 ,,	+1·20 ,,
Tezpur	73·08 ,,	73·17 ,,	+0·09 ,,
Silchar	121·43 ,,	123·14 ,,	+1·71 ,,
Jalpaiguri	125·72 ,,	122·32 ,,	—3·40 ,,
Darjeeling	121·80 ,,	122·67 ,,	+0·87 ,,

The gains or losses are in most cases small and no greater than might be reasonably expected.

The monthly averages up to 1900 differ very little from those up to 1920. The figures for Sibsagar illustrate what order of variation may be expected.

Average monthly rainfall at Sibsagar.

Month.	Up to 1900.	Up to 1920.
January	1·14 ins.	1·24 ins.
February	2·16 ,,	2·02 ,,
March	4·74 ,,	4·78 ,,
April	9·88 ,,	10·15 ,,
May	11·47 ,,	11·52 ,,
June	14·14 ,,	14·31 ,,
July	15·89 ,,	16·83 ,,
August	16·29 ,,	16·33 ,,
September	11·77 ,,	11·56 ,,
October	5·17 ,,	5·16 ,,
November	1·11 ,,	1·10 ,,
December	0·59 ,,	0·54 ,,

(2) Walker, G I., Monthly and Annual Normals of Rainfall and Rainy Days, *Mem. Ind. Met. Dept.*, Calcutta, 1924 (vol. XXIII, pt. VII).

As a result of the study of available records it can be concluded that the rainfall in North East India is not changing appreciably.

The Effect of Forests on Rainfall.

In connection with suggestions regarding the change in the climate of Assam it is often supposed that forests have a great influence on rainfall and that the gradual deforestation of the province, slow though it is, may be a menace to the future.

Forests have a considerable influence on water run-off, for they store water and dole it out gradually thus preventing floods and ravine formation. The increased size of river beds during the past few years in parts of the Dooars is attributed in some cases to deforestation of the foothills, and the cutting down of forests has led to the flooding and, in some cases, the actual loss of considerable areas of tea.

The effect of forests on the actual precipitation, however, is probably very small, although any direct estimate of this factor is difficult to obtain owing to lack of records. In a recent discussion on this subject (3) it has been pointed out that the replacement of forests by field crops actually increases the rainfall slightly by virtue of the moisture transpired by the crop, which is greater than that transpired by the forest. The replacement of forests by bare ground on the other hand tends slightly to decrease the rainfall because of the entire removal of vegetation capable of transpiration. Transpiration of plants returns moisture to the atmosphere which may then be re-precipitated as rain.

Forests increase the local rainfall slightly, by one or two per cent., this effect being due to the increase in the effective level of the ground by the height of the trees. In favourable mountain situations some increase in rainfall on account of forests is shown by virtue of the extra moisture collected mechani-

(3) Brooks, C.E.P., The Influence of Forests on Rainfall and Run-off, *Quar. Jour. Roy. Met. Soc.*, London, 1928 (vol. 54, no. 225).

cally from clouds which envelop the forest. This effect would be marked in the Darjeeling district especially in the areas above the "mist-line" at 4,000 to 4,500 feet (see this Journal, pt. II, p. 83, 1926). In fact Mann pointed out that the records of some of the Darjeeling spurs showed a slight falling off in precipitation as deforestation proceeded (1).

The afforestation of grass or crop land probably increases the local run-off by 10 to 20 per cent., this amount being made up partly by decreased loss of water in evaporation and transpiration, partly in the slight increase of actual rainfall. Afforestation of bare land decreases the run-off, but this effect is masked by the much greater regularity of the flow of the run-off water.

Forests, drawing their water supply from deep sources, possible exercise a slight mitigating effect on droughts.

Summing up the evidence on the matter it may be concluded that the deforestation of North East India and the planting of rice and tea will not seriously influence the rainfall either way.

One interesting effect of deforestation has been observed in the Doom Dooma district, and that is the increase in the intensity of the cold weather mists as forest areas have been opened up. This observation is only a casual one and has no records to substantiate it, but it is undoubtedly a correct one. The removal of forests makes for a less equable temperature and an increased tendency to mist formation.

Rainfall at Tocklai in 1928.

The spring of 1928 was totally different from that of 1927. In the first four months of 1928, 6.63 inches of rain were recorded against 18.47 inches in 1928. One result of the 1928 drought was the failure of unpruned tea and of unshaded nurseries.

The Monsoon arrived on June 17th, although heavy falls were registered before this date. June was an exceptionally wet month and July exceptionally dry. Both September and October were very wet. The Monsoon, judged from the wind direction and absolute humidity values, ended on about the 15th of the latter month. After this date, however, there were several generous falls. The Monsoon in Assam may be said to have been a weak one in 1928, judged not from actual rainfall but from the wind direction and its steadiness.

The table below shows the average rainfall at Tocklai and that recorded in 1928.

Rainfall at Tocklai.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average	0·93	1·47	3·43	7·75	9·09	13·51	16·14	13·16	11·29	4·87	0·97	0·30	82·51
1928	0·18	0·57	1·51	4·38	8·35	19·63	10·32	11·71	16·29	7·43	1·65	*nil.*	82·02

Sunshine.

The 1928 season was a very sunny one, each month except October showing either an equal or greater number of hours of bright sunlight than the average. The tables below show the Tocklai average values for monthly hours of sunshine together with the 1928 values recorded at Tocklai, Katonibari and Doom Dooma. Katonibari is about 8 miles from Tocklai, towards the Naga Hills. The Doom Dooma values were taken at Pabhojan.

Sunshine in hours per mensem.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Tocklai												
Average	164	177	177	141	146	126	124	136	117	180	168	167
1928	197	245	252	230	161	120	192	167	142	135	167	180
Katonibari												
1928	147	237	247	220	140	93	174	180	133	142	183	192
Doom Dooma												
1928	245	205	186	203	145	107	160	155	121	119	191	187

The rainy period experienced in March in Doom Dooma is reflected in the low sunshine value for this month.

The Soil Condition.

The soil moisture during the earlier part of 1928 presented a distinct contrast to that in the same period of 1927. The table below shows the soil moisture during the two years and also the average monthly soil temperature taken at depths of 1 foot and 3 feet.

Soil moisture and temperatures at Tocklai during 1927 *and* 1928.

	1927			1928		
	Soil moisture.	Soil temperature.		Soil. moisture.	Soil temperature.	
		1 ft.	3 ft.		1 ft.	3 ft.
January ...	15%	65°F	67°F	12%	65°F	67°F
February ...	15%	65°F	67°F	11%	67°F	69°F
March ...	15%	70°F	70°F	10%	72°F	72°F
April ...	18%	77°F	75°F	13%	80°F	79°F
May ...	18%	81°F	80°F	17%	81°F	81°F
June ...	19%	87°F	85°F	19%	85°F	84°F
July ...	19%	87°F	85°F	18%	88°F	86°F
August ...	19%	87°F	86°F	19%	88°F	87°F
September ...	20%	84°F	84°F	19%	86°F	85°F
October ...	19%	81°F	82°F	19%	82°F	83°F
November ...	16%	73°F	76°F	18%	73°F	77°F
December ...	13%	68°F	70°F	19%	66°F	70°F

It will be observed that the dryer soil showed higher temperatures throughout the drought period. However, since soil temperature is a minor factor compared to soil moisture, the start of the season in 1927 was much earlier than in 1928. Without sufficient moisture nitrate formation is retarded, which in turn checks the crop.

In April of this year (1928) additional soil thermometers were installed at Tocklai. During the past 7 years the soil temperature has been recorded at 1 ft. and 3 ft. on the grassed plot which constitutes the meteorological station. One additional thermometer has been placed at 1 ft. in the tea near the grassed plot

and two thermometers, one at 1 ft. and one at 3 ft., on a clean fallow plot some distance away.

The tea in which the soil thermometer is placed is fully grown and gives complete shade to the soil in the rains. As might be anticipated, the soil under tea was cooler than that under grass. In April the difference in temperature at 1 ft. averaged 2° F. By August the difference had increased to 4° F., after which it gradually decreased to 1.4° F., in November and 0.7° F., in December, after the tea had been pruned.

The clean fallow plot also showed lower temperatures than the grassed plot. At both 1 ft. and 3 ft. the temperature varied from 1° F., to 2° F., below that on the grassed plot throughout the period April to December.

The Weather Chart for 1928.

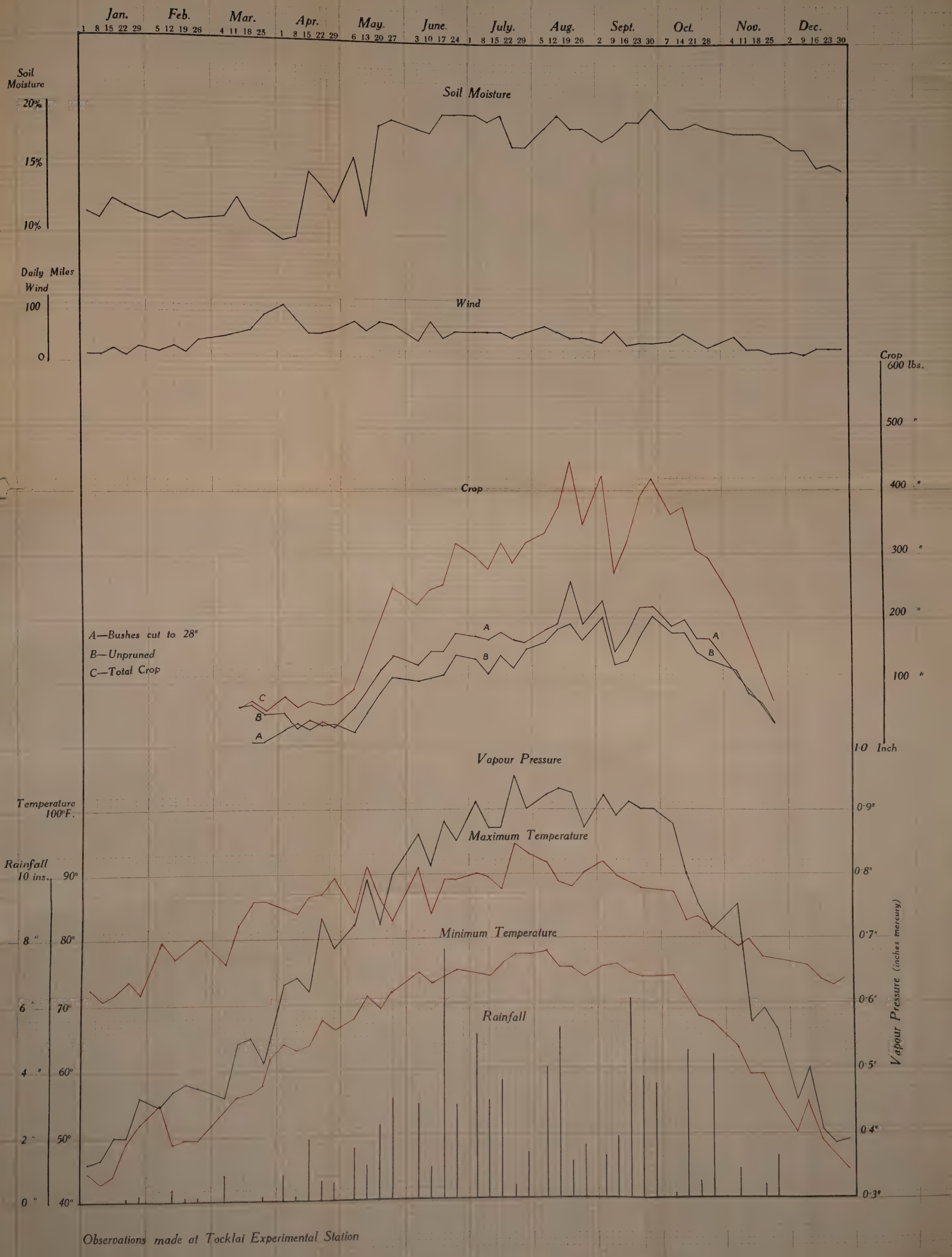
The weather chart, shown opposite, is drawn on lines identical with those adopted in the meteorological reports of the past few years. The top curve indicates soil moisture, a factor discussed above.

Before the first good fall of rain was recorded, the soil became very hot with the result that after the first rain, nitrate formation was usually rapid. This was followed by a ready response in leaf late in May. In the interval, however, the unpruned tea had failed and it never recovered.

The wind average, shown on the second curve, was normal. An absence of cyclones may again be recorded for the fourth year in succession.

The green leaf from the Tocklai clearance, an area of about 2½ acres, is taken for correlation with weather and soil conditions. Whereas during last season (1927) the crop started somewhat late because of the cold wet soil, this season the start was delayed, in a much more serious manner, by an over dry soil. Later conditions were good and the low rainfall in July made

SEASON 1928



Observations made at Tocklai Experimental Station

August a good cropping month. The end of the season was a normal one in Assam.

The 1928 Season in the Dooars.

The season in the Dooars is generally considered good or bad according to the severity of tea mosquito (*Helopeltis theivora*) attack. One of the controlling factors in the attack is the weather. Whether the climatic effect is exerted mainly through its influence on the rate of reproduction of the insect itself or through some modification in the tea leaf which renders it palatable or otherwise to the pest or through its influence on the rate of growth of the tea shoot, is not a question to be discussed here.

In a previous report on weather conditions in the Dooars, (this Journal, pt. II, 1926) it was pointed out that, from a study of the yields of tea per acre from 1896 to 1924, it could be shown that banner years in the Dooars generally corresponded with those in the Assam Valley and *vice versa*. In the latter area mosquito is negligible, and the conclusion was drawn that much of the crop variation attributed to the severity or otherwise of mosquito attack was due primarily to unfavourable weather conditions.

Taken as a whole, the 1928 season in the Assam Valley was a good average one, partly on account of the fact that in the districts of Upper Assam good rains were recorded in March. The 1928 season in the Dooars was a poor one. Although early on in the season many gardens did well, mosquito developed so rapidly in August that the back-end was, in many cases, almost a complete failure.

In examining weather conditions in connection with mosquito attack, a study of the sunshine records, unfortunately very incomplete, taken during the past four years at Sylee is of great importance. The seasons 1926 and 1927 were comparatively free from mosquito. The present season (1928) was exceptionally bad and 1925 fairly bad. The table below shows the sunshine, as far as the records go, over the past four years.

Sunshine at Sylee in hours per mensem.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1925	.....	.....	.....	118	101	124	94	96	86	.....	.....	.....
1926	.....	.....	.....	180	147	91	68	127	170	.....	.....	.....
1927	.....	.....	190	217	216	144	114	149	144	223	196	142
1928	190	232	255	109	169	91	111	123	133	171	.....	.....

It is, of course, impossible to correlate mosquito attack and sunshine with the limited data available, especially since only two figures for March, perhaps the most critical month, are on record. However, the March sunshine in 1928, representing as it does an average of just over 8 hours of bright sunshine a day, indicates the fierceness of the drought.

Other months which are considered in the Dooars to be critical ones in connection with mosquito attack are August and September. If these months are dull and wet the attack is assumed to be encouraged. The sunshine records for the four seasons 1925-28 do not lend this theory support.

October 1928 was a dull month and, although the mosquito damage was done earlier than this, lack of sunshine at this period no doubt helped to reduce the crop at the close of the season.

Regarding some of the other climatic factors in the Dooars during 1928, the table below shows the Sylee average monthly rainfall and that in 1928, together with the monthly average temperatures in 1928 as far as they are available. The temperatures were obtained under standard conditions and are directly comparable with those taken at Tocklai. For purposes of comparison the average monthly rainfall and the 1928 rainfall and temperatures recorded at Tocklai are shown.

Rainfall and Temperatures at Tocklai and Sylee.

Month.	Tocklai.				Sylee.			
	Maximum 1928.	Minimum 1928.	Rainfall 1928.	Average.	Maximum 1928.	Minimum 1928.	Rainfall 1928.	Average.
	°F.	°F.	ins.	ins.	°F.	°E.	ins.	ins.
January	73·5	47·8	nil.	0·93	73·2	44·5	0·04	0·47
February	78·8	50·6	0·57	1 47	80·4	52·3	0·08	0·74
March	83·2	58·2	1·51	3·43	86 7	58·7	1·40	1·12
April	87·1	65·1	4·38	7·75	89·1	66·5	1·78	3·99
May	87·0	70·7	8·35	9·09	86·6	69·6	16·19	11·09
June	88·7	74·4	19·63	13·51	.....	.....	31·43	33·43
July	91·0	75·9	10·32	16·14	.....	.....	36·92	44·56
August	89·6	75·3	11·71	13·16	88·9	74·7	28·86	28·21
September	88·8	74·8	16·29	11·29	88·7	74·1	35·07	28·07
October	82·9	70·2	7·43	4·87	84 5	68·0	21·10	7·49
November	76·9	56·5	1·65	0·97	.....	.....	2·68	0·98
December	73·6	48·5	nil.	0·30	.....	.....	nil.	0·19

In the first five months of the year there was little difference between Tocklai and Assam temperatures. Reference to the sunshine tables also shows a close similarity between the two places over this period. The early drought at Sylee in 1928 was, however, much more severe than at Tocklai.

The difference between average conditions in the two areas becomes apparent in the wet months, during which there is much more precipitation and much less sunshine in the Dooars than in Assam. These differences hold every season, and the rains in 1928 in the Dooars do not appear to have been so much out of the ordinary to account for the severity of the mosquito attack.

Hence it appears from the limited data available, that the influence, direct or indirect, which climatic conditions had on the severity of mosquito attack in 1928 was exerted chiefly during the early drought since later conditions, prior to the shutting up of the bushes, appear to have been about normal.